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IN WESTERN COLORADO USING ERTS-1 DATA: PROGRESS REPORT VI

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Daniel H. Knepper (Compiler)
Department of Geology
Colorado School of Mines
Golden, Colorado 80401

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PREFACE

On 30 June 1972 a contract was awarded to the Colorado School of Mines for research in the interpretation of ERTS-1 imagery and supporting aircraft data and their application to mineral and water resources investigations. This work is being done by five faculty members and two graduate student research assistants in the Department of Geology and by research scientists in the Planetary Geology Laboratory at Martin-Marietta Corporation/Denver Division. The work consists primarily of the following studies:

- 1) Identification and discrimination of
 - (a) rock types and surface composition
 - (b) geologic structures
 - (c) geomorphic phenomena
 - (d) mineral resources
 - (e) water resources
 - (f) volcanic phenomena
- 2) Evaluation of ERTS imagery for geologic applications
- 3) Processing and enhancement techniques applied to ERTS imagery
- 4) Atmospheric effects on remote sensing data

Snow-free ERTS images covering most of Colorado have been received, however, most of the central and north-central part of the state has been obscured by moderate to heavy cloud cover

on each ERTS overpass. Nearly cloud-free imagery was acquired over the central and western part of the state during December and January; this winter imagery has considerable snow cover, but the snow, combined with the low-angle of solar illumination, has been instrumental in mapping topographically-expressed structures and landforms not detected on the high sun-angle, fall imagery.

Side lap of approximately 30 percent, at Colorado latitudes, permits stereoscopic viewing of about 65 percent of each image. This is of great value in geologic analysis, and terrain analyses in general. If at all possible, complete stereoscopic coverage should be obtained, perhaps by offsetting the ERTS-2 ground track one-half frame from that of ERTS-1.

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INTRODUCTION

This report summarizes the work conducted by the Colorado School of Mines during the period 1 December 1972 - 31 May 1973 under contract NAS5-21778 to the National Aeronautics and Space Administration/Goddard Space Flight Center for the purpose of investigating the application of Earth Resources Technology Satellite (ERTS) data for identifying and discriminating geological phenomena in central and western Colorado. Effects of the atmosphere on remote sensing data are also being investigated.

During the report period researchers at the Colorado School of Mines and the Planetary Geology Laboratory at the Martin-Marietta Corporation/Denver Division have investigated the utility of ERTS-1 imagery for discriminating the various rock types and soils exposed in central and western Colorado. Geologic structures including folds, faults, and fractures and fracture systems have been mapped on ERTS imagery and the results compared to published geologic and tectonic maps. Photo-lineament data derived from ERTS imagery interpretation, presumably representing crustal faults and fractures, have been statistically analyzed for location and distribution of significant trends utilizing computer analysis techniques. Structural information derived from ERTS imagery interpretations is also being used in an investigation of the capability of ERTS imagery for locating

structurally-controlled metallic mineral deposits in the Colorado Mineral Belt.

Atmospheric measurements of direct, total, and diffuse solar radiation were made during several ERTS-1 passes over central Colorado with the aim of providing atmospheric data which can be used to computer-correct ERTS/MSS magnetic tape data. The measurements were analyzed for optical depth and the absolute quantities of total and diffuse solar radiation.

Experiments were conducted on the construction of color composites of various combinations of ERTS bands for optimum use in geologic interpretation. The color composites were made by exposing the various ERTS bands on colored Diazo proofing film.

ERTS-1 DATA INTERPRETATIONS

IDENTIFICATION AND DISCRIMINATION OF LITHOLOGY

As we gain interpretive experience using ERTS imagery, it is becoming apparent that this experience plays a large part in the degree of success achieved in lithologic discrimination. Since photointerpretation is a highly subjective procedure, familiarity with the scene gained by repetitive image examination and field inspection also improve the results obtained. Furthermore, it is not entirely realistic to discuss lithologic discrimination separately from geomorphic and structural evaluation. Geologic interpretation of a particular area is dependent on recognition of the distribution, continuity and trend of key surface features. In the examination of ERTS imagery, especially, lithology and structure must be interpreted largely from the geomorphic expression of the terrain.

The following observations are made on the interpretation of two ERTS-1 images, E-1028-17135 and E-1027-17081 which, together, provide stereoscopic coverage of the Canon City-Cripple Creek test area.

Examination of ERTS imagery alone, independent of any other knowledge, is sufficient to classify the mountainous terrain north of Canon City as a crystalline complex characterized

by rugged topography, moderate textured drainage dissection, and extensive rectangular lineation due to jointing and faulting of the crystalline rocks. The contact of the crystalline rock with the overlying sedimentary formations is easily delineated, particularly in stereoscopic view. Within the sedimentary formations, many discrete units such as the light-colored Carlisle Shale lying stratigraphically above the conspicuous sandstone hogbacks of the Dakota Formation are easily traced eastward from Canon City for distances of 50 km or more. Ridge lines formed by steeply dipping, resistant strata exhibit a dark tonal pattern on the ERTS images and local folds and faults are particularly evident where the strike and continuity of the hogback ridges change abruptly. Several intervening valleys, probably underlain by shale, are also clearly evident on the basis of their light tonal character.

The overall spectral character of the rocks in the area under examination seems to have a great influence on the degree of success achieved. One of the primary goals of our ERTS-1 investigations was to assess the imagery for its capability to display the contact between two major intrusive bodies, the Pikes Peak batholithic granite and the adjoining Cripple Creek and Silver Plume granites, extending for at least 35 km between Lake George and Cripple Creek. Color aerial photography shows the contact very well where it is displayed by a distinct topographic alignment as well as by a tonal change. On ERTS-1 imagery, the contact is barely seen at all.

A similar situation exists with respect to differentiation

of the Pikes Peak Granite from the andesitic and basaltic flows and breccias of the Thirty-nine Mile volcanic field. Although the two rock types can be easily discriminated using high-altitude aerial photography (NASA mission 205, 1:110,000), they appear virtually the same on the ERTS images. One of the reasons for this is undoubtedly the effect of vegetation as discussed earlier by Knepper (4). This general subject will be investigated further in our image enhancement experiments.

IDENTIFICATION AND DISCRIMINATION OF GEOLOGIC STRUCTURE

General

The usefulness of ERTS-1 imagery in displaying regional geologic structure is immediately obvious. A case-in-point is the easy recognition of ERTS-1 images of the 17 km-by 32 km oval which shows the coherent structural nature of the Pikes Peak plutonism. Hutchinson (3) has discussed the Pikes Peak intrusive complex as one of three comprising the major Pikes Peak batholith.

One unexpected attribute of the ERTS-1 imagery is the relative accuracy with which dip can be estimated in stereoscopic views. An experiment was conducted involving two photogeologists experienced in estimating dips as seen on aerial photographs. Using a simple 2X pocket stereoscope, estimations were made of dip magnitude which were within 2-to 6 degrees of field measured dips.

One drawback encountered on the interpretation of 1:1,000,000 ERTS imagery is that more geologic information is observable than can be graphically annotated on the image overlay. With

this in mind, paper print enlargements at a scale of 1:500,000 have been ordered which should enable the annotation of a much greater amount of geologic detail.

Mapping Fold Structures Within Sedimentary Basins

Following the examination of a number of sedimentary basins in Colorado, the northwestern corner of the state was selected to test the capability of detecting fold structures on ERTS-1 imagery. The area includes the Piceance and Uinta basins and portions of the Uinta and White River uplifts bordering the basins on the north and east. The sedimentary strata exposed in the area contain numerous second-order folds (anticlines and synclines) of which the interpreter had no previous detailed knowledge.

A total of 55 folds were present in the area covered by one ERTS-1 scene (5). On a high sun-angle (42°), snow-free ERTS-1 image acquired in the fall of 1972 (E-1066-17245-4,5,6,7), only 14 folds were detected, due presumably to their obvious outcrop patterns. A low sun-angle (21°), partially snow-covered ERTS-1 image of the same area (E-1156-17253-4,5,6,7) was analyzed next. In this case, a total of 40 folds were delineated.

Recognition of fold structures on ERTS-1 imagery of northwestern Colorado is attributed to 1) distinctive outcrop pattern, 2) distinctive tonal pattern, 3) opposing dip slopes, 4) diagnostic stream patterns, and 5) topographic expression of ridges or ridge patterns. The increased mapping capability demonstrated on the low sun-angle illumination ERTS-1 images

strongly suggests that characteristic topographic patterns may be the most important factor in detecting folds in the sedimentary strata of northwestern Colorado.

Fracture Analysis

Investigation continued on evaluation of the recognition and mapping of faults and regional fracture patterns from linear features on ERTS MSS imagery. Emphasis in this phase was on developing a method for producing computer-compatible data, modifying existing computer programs, and making the first computer-assisted analyses of the linears.

All linear features on a positive image are traced onto a clear overlay. On orbital imagery, the objectivity of tracing all linears is more justifiable than on low-altitude imagery where cultural features such as landlines constitute a large part of the data. However, in the final analysis, trends due to these sources can be easily interpreted and discarded if desirable

Azimuths of the linears and segments of curvilinears are measured with an azimuth-indexed turntable. Data are recorded for 16 equal areas of the image on data forms compatible with computer card format.

The computer program accepts azimuths for input and produces printer lists and plots for analysis. The first plot produced is an absolute strike-frequency graph on 1-degree intervals. The range of the graph is 180 degrees from N.90W to N.90E. The second plot is an empirical frequency graph similar to the

first. It is constructed by smoothing the absolute frequency data over a 3 percent interval of the 180-degree range. This graph is used in the statistical significance test.

The two plots are followed by two tables. The first is a table of significance levels for the values of empirical frequency. The significance levels are calculated from the binomial distribution, the number of azimuths, and the smoothing factor. In general, levels greater than 0.5 are significant and values above 0.9 are very significant.

The second table contains azimuths and values of the maxima in the empirical frequency data. The azimuths of the maxima of maxima in the table are the main trends of the linears. Maxima frequencies, and therefore their significance values, are interdependent; that is, large numbers of one trend can conceal trends of small number. This is acceptable so long as the trends are all of the same origin. It may be desirable to recognize and discard data of landlines or roads and reanalyze the remainder.

The method was applied to ERTS MSS image E-1154-17143 covering the Canon City and South Park, Colorado areas. Less than 5 percent of the linears could be directly attributed to cultural features. A few percent are due to structures in sedimentary rocks and most are from igneous and metamorphic terrains. For the whole area eight significant trends were found. Some are parallel to known regional trends, for example the prominent N5-30W trend of the Front Range block mountain. Table 1 shows a comparison of ERTS linear trends with joint patterns of

eastern South Park (6). Trends are strongly area dependent, each being found in less than half of the 16 subdivisions of the imaged area. As a result trends that are significant in the whole area may not be significant in given subdivisions and vice versa as shown in Table 1. These results are preliminary and the investigation will be extended to include more joint data and other ERTS images of the same area.

A number of modifications and applications will be made to the method of analysis. The computer program will be modified to accept the lengths of linears as weighting factors of the frequencies. This will increase the significance of long, isolated linears with respect to short, closely spaced ones.

Applications will be made to imagery at larger scales and to geologic data. Through autocorrelation of empirical frequency graphs of the imagery and the geologic maps of an area, an evaluation of geofracture mapping from imagery will be made.

GEOMORPHIC EXPRESSION

Geologic interpretation of ERTS imagery, because of the scale, is particularly dependent on the geomorphic character of the terrain being examined. Lava flows in areas devoid of vegetation are conspicuous on ERTS images (e.g., North and South Table Mountain near Golden). Fractures, faults, and joint patterns when observed on ERTS images are usually conspicuous because of the associated straight-line drainage

TABLE 1. Comparison of ERTS MSS 1154-17143 linear trends with joint trends of eastern South Park.

ERTS image		eastern South Park	
whole area	South Park area	joint trends	origin
	N66-73W	N75W	Laramide
	N52W	N50W	older Precambrian
N39W	N35W		
N20-28W		N26W	Laramide
N3-12W			
N5E			
N12-21E	N8-12E	N12E	younger Precambrian
N28-38E N49-52E	N28E	N44E	older Precambrian
N81E		N72E	Laramide

patterns, a geomorphic expression. A different drainage pattern observed repeatedly on the ERTS imagery as well as the high altitude aerial photography has led to a new awareness of the relatively large number of circular features in the Precambrian crystalline rocks of the Front Range. The more one looks, the more one sees recognizable concentric stream patterns.

Hutchinson (3) has described some of the bigger and more obvious of these features. Others ranging from a few kilometers to 15 km in diameter (Virginia Dale Ring dike) are visible in the Front Range between Pikes Peak and the Colorado-Wyoming border. Most of the observed features are not currently shown on published maps and are only readily recognizable on the perspective afforded by the small-scale ERTS imagery and high-altitude aerial photography.

MINERAL RESOURCES

A study is being conducted to determine the capability of using ERTS-1 imagery to locate areas of known mineralization in the Colorado Mineral Belt and to locate, if possible, potential target areas in areas thought previously to be unmineralized. Although the study has barely begun, some preliminary results warrant discussion.

Analysis thus far indicates that Tertiary intrusive bodies associated with metallic mineralization along the Colorado Mineral Belt cannot generally be discriminated from the surrounding country rock. Similarly, alteration associated with known mineralized districts has not been directly detected on any ERTS-1 imagery studied.

Detailed mapping of photo-linears (faults, shear zones, etc.) on ERTS-1 images, however, has proven successful in defining many of the major mining districts in the Mineral Belt. The mineralization in these districts is found in faults and fractures, and the largest ore bodies are commonly found at the intersections of major fractures or fracture systems.

Many previously unmapped through-going linears have been mapped and many fracture intersections have been plotted; these potential targets of mineralization will be studied on available aerial photos and the most promising targets will be visited in the field.

Circular, or curvilinear, features mapped on ERTS-1 images have, in many cases, been associated with known intrusive bodies or volcanic centers and collapse calderas. The features are also commonly sites of mineralization. Several circular features not known to be associated with mineralization will be investigated further using aerial photos and field work.

In summary, these very preliminary results indicate that ERTS-1 imagery appears to be most useful for detecting structural features which may control the location and distribution of metallic mineral deposits in the Colorado Mineral Belt.

ATMOSPHERIC EFFECTS ON REMOTE SENSING

Atmospheric effects measurements have been made for the 16 February 1973 overpass of ERTS-1. Measurements of direct, total, and diffuse solar radiation were made at two sites, Eleven Mile Reservoir (South Park) and Granite Hills. Spectral regions covered are those of the four bands of the MSS.

An ISCO spectroradiometer, modified somewhat for our specific applications, was used at the Granite Hills site, and a recently developed Bendix Model 100 Radiant Power Measuring Instrument (RPMI) was used at the Eleven Mile Reservoir site. The use of the Bendix instrument was coordinated with Dr. R. Rogers of Bendix, who is an ERTS-1 principal investigator. The 16 February measurements using the RPMI represent some early field evaluations by an ERTS-1 investigator, other than Dr. Rogers. The Model 100 was developed under NASA/G.S.F.C. contract to Dr. Rogers.

The atmospheric conditions for the 16 February overpass were ideal; no clouds were present and atmospheric aerosols appeared to be at a minimum. All measurements have been analyzed for optical depth and the absolute quantities of total and diffuse solar radiation. The optical depths for each MSS band shows a measurable difference between the sites. This difference is attributed to an altitude difference of 800 feet.

The magnitudes and differences of optical depth are being compared to existing atmospheric models published by A.F.C.R.L.

(2). Preliminary comparisons indicate that the measurements are in the general range of the 23 km visual range model. However, the measured values of optical depth for the Colorado Test Site (Granite Hills and Eleven Mile Reservoir) are even less than the most tenuous aerosol model (23 km visual range).

The measured values of optical depth and total and diffuse solar radiation are being forwarded to the Environmental Research Institute of Michigan (ERIM). Dr. Thomson and Dr. Turner of ERIM will then introduce these measurements into their existing computer programs in order to correct the 16 February MSS data for atmospheric effects. Dr. H. Smedes of the U.S.G.S. will then compare the corrected and uncorrected automatic computer terrain maps in order to evaluate the impact of the atmospheric corrections.

In order to fully evaluate the radiative transfer programs used for correcting the MSS data of ERIM, measurements of snow reflectance were also made at the Eleven Mile Reservoir site. Measurements of snow reflectivity were made by viewing standard reflectance panels (gray and white), calibrated for each of the MSS bands using a Beckman DK2 reflectometer. The R.P.M.I. was used to measure the radiance from the gray panel, the white panel, and the snow. By doing this the reflectance of the snow was determined. In order to assess the degree of uniformity of the snow cover, a total of six different sites was measured. It was found that for MSS band 1,

the reflectance varied from 83-86%, for band 2 it varied from 83-87%, for band 3 it varied from 82-87%, and for band 4 it varied from 73-79%. The actual magnitude of the snow radiance during the actual overpass was measured to be: Band 1 - 42.0 watts per meter² per steradian; band 2 - 37.4 watts per meter² per steradian; band 3 - 31.8 watts per meter² per steradian; and band 4 - 55.5 watts per meter² per steradian.

The above measurements of snow reflectance, along with the corresponding measurements of atmospheric optical depth, at the Eleven Mile Reservoir site will allow ERIM to evaluate their computer corrections. This will be done by first calculating the snow radiance and reflectance using the measurements of optical depth with the radiative transfer models, and then comparing these calculations with the actual measurements.

In order to perform the measurements of optical depth, reflectance, total radiation, and diffuse solar radiation, detailed laboratory calibrations were made for the Bendix R.P.M.I. and the ISCO. Calibration factors were derived that allowed absolute quantities to be obtained. These factors were compared to those derived by Bendix (Dr. R. Rogers) and NASA/G.S.F.C. (using the Hovis Sphere). According to Bendix, all factors were in good agreement with each other.

INTERPRETATION, PROCESSING AND ENHANCEMENT TECHNIQUES

One method of image interpretation is so basic and, at the same time, so valuable that we must pay particular attention to it here. That interpretive technique is the stereoscopic interpretation of overlapping (sidelap) ERTS images. By judicious selection of imagery from adjacent satellite tracks, approximately 65% of each ERTS-1 image at our latitude (39°N) can be viewed in stereo. As stated earlier, in the examination of ERTS imagery, lithology and structure must be interpreted largely from the geomorphic expression of the terrain. Because geomorphology involves the recognition and proper interpretation of land forms, the ability to perceive the relationship of related topographic features, their relative elevation, slope, or roughness is vital. The use of stereo is particularly valuable in the discrimination of relief, relative rock resistance and qualitative dip estimation. Stereo viewing provides a number of additional advantages over monoscopic viewing. Since adjoining images (sidelap) are separated by a minimum of one day in time, clouds which obscure ground detail in one image are often absent in its "stereo-pair." Thus the interpreter, while viewing both images simultaneously, tends to filter out the "image-noise" of the cloud and is left free

to concentrate on the ground detail. The absence of a stereo model in the limited region covered by clouds on one of the two images of the stereopair does not seriously disrupt the continuity of the entire three-dimensional scene, once a mental image of the overall scene is established. The same process of "noise-filtering" applies to film scratches and processing imperfections of all kinds as well as to differences in illumination (cloud shadows) or other visibility-limiting phenomena such as thin, virtually indistinguishable layers of cirrus clouds or snow cover. A serious loss of interpretability is noted when going from a stereoscopic model on the two edge strips of each image to the center monoscopic mode on the center 1/3 part of each strip (satellite track). The alteration of orbital path to provide a minimum of 55% sidelap coverage of each track is strongly recommended in future operations.

We are also experimenting with inexpensive methods of color constitution of ERTS-1 images based on the note by Bowden and Johnson (1). This process involved exposing the various ERTS bands on colored Diazo proofing film. The Clark systems multispectral projector Model 5005 is used to establish the band/color/intensity combinations which seem to best enhance the features of interest. Many combinations can be examined rapidly with this system although the resulting format (image as projected onto a ground-glass screen) is not suitable for detailed analysis. The best results using the colored Diazo film has been in simulating color-IR images. The

initial relative color intensity to be used with each band was established with the multispectral projector. The exposure of the Diazo film is controlled, within limits, by regulating the operating speed of the Diazo machine. First generation composites were made using relatively thin Diazo film exposures that appeared to have the most tonal variations. However, it was found that superior renditions result from using relatively dense exposures. Most of the composites used bands 4 and 5 plus either band 6 or band 7 but a very good composite was constructed using bands 4 and 5 plus both infrared bands (MSS 6 + 7).

Geomorphic features are enhanced and more easily interpreted on simulated color-IR composites. A striking example of this enhancement is seen by comparing B/W transparencies and the color-IR composite of the Canon City area. The hogbacks (Paleozoic section) north and northeast of Canon City are vividly depicted on the color composite but are relatively vague on the B/W transparencies. The reason for this difference appears to be due to both greater tonal contrast and color contrast between the hogbacks and the surrounding area on the composite image. The color-IR composite does an excellent job of discriminating general vegetation type and variations. This ability results in high detectability and enhancement of drainage systems due to characteristic variation associated with slope and moisture.

SIGNIFICANT RESULTS

LITHOLOGIC SURVEYS

Lithologic discrimination based only on the spectral information content of ERTS-1 images is generally poor. Some discrimination can be accomplished in exposed sedimentary terrain, but more commonly the ability to map lithologic units on ERTS-1 imagery is governed by other factors. Geologic interpretation of a particular area is dependent on recognition of the distribution, continuity, and trend of key surface features. In the examination of ERTS-1 imagery, lithology must be interpreted largely from the geomorphic expression of the terrain.

STRUCTURAL SURVEYS

ERTS-1 imagery is extremely useful in mapping regional geologic structures, and is commonly useful in detecting locally-developed structures. Folds, faults, and fractures and fracture systems have been successfully mapped. Most of the structure studied, thus far, are expressed in the topography of the terrain. Consequently, ERTS-1 imagery acquired in mid-winter, when solar illumination is at its lowest angle to the horizontal, has provided the largest amount of structural information.

MINERAL EXPLORATION

Metallic mineral deposits in the Colorado Mineral Belt commonly occur along major crustal fractures, and particularly at the intersections of major fractures. Many, if not most, of the fractures are expressed in the topography of the terrain. Low sun-angle ERTS-1 imagery acquired in December 1972 and January 1973 reveals many topographically-controlled linear features not detectable on high sun-angle ERTS-1 imagery. Many of these linears, and the intersections of linears, can be correlated with known mining districts, suggesting that careful, detailed study and evaluation of ERTS-1 imagery structural interpretations may provide a means for extending known mineralization trends into new areas or discovering new areas of potential mineral deposits.

PROGRAM FOR NEXT REPORTING PERIOD

During the next reporting period emphasis will be placed on the geologic interpretation of ERTS-1 imagery and supporting aircraft data. The primary goals of ERTS-1 imagery analysis will be 1) to determine what kind and scale of geologic phenomena can be interpreted from the imagery alone, from space data plus aircraft data, and from space data, aircraft data, and ground data combined, 2) to determine which spectral bands are best suited for geologic interpretation in Colorado, and 3) to investigate various interpretative techniques including conventional photogeology, stereoscopic analysis, color additive veiwing, color video image processing, and analog electronic processing of ERTS-1 magnetic tape data.

Field checking of ERTS data interpretations and detailed field studies of selected areas will be performed during June, July, and August 1973.

NEW TECHNOLOGY

No new technology was developed during the time period covered by this report.

CONCLUSIONS

Lithologic discrimination based only on the spectral information content of ERTS-1 images is generally poor. Some discrimination can be accomplished in exposed sedimentary terrain, but in general, the ability to map lithologic units is governed by other factors. Geologic interpretation is dependent on recognition of the distribution, continuity, trend, and geometry of key surface features. In the examination of ERTS-1 imagery, lithology must be interpreted largely from the geomorphic expression of the terrain.

ERTS-1 imagery is extremely useful for mapping regional geologic structures, and is commonly useful in detecting locally-developed structures. Folds, faults, and fractures and fracture systems have been successfully mapped. Most of the mapped structures are expressed in the topography of the terrain. Consequently, ERTS-1 imagery acquired during mid-winter, when solar illumination is at its lowest inclination, has provided the largest amount of structural information.

Photo-lineament mapping of the low sun-angle ERTS-1 imagery revealed many topographically-expressed linear and curvilinear features not detected on high sun-angle imagery. Many of these linears, and the intersections of these linears, can be correlated with known mining districts in the Colorado Mineral Belt. Detailed study and evaluation of ERTS-1 linear data, combined with

aircraft data analysis and field studies, may provide a means for extending known mineralization trends into new areas or for discovering new target areas for potential mineral deposits.

The results of geologic interpretation of ERTS-1 imagery of most of central and western Colorado indicate that the images can be effectively applied to regional geologic studies and, hence, toward meeting the objectives of this investigation. Stereoscopic analysis of ERTS-1 images, where possible, significantly increases geologic interpretation capability for lithologic discrimination and structural analysis.

RECOMMENDATIONS

Based on the preliminary results of geologic interpretations of ERTS-1 images of western and central Colorado, it has been found that use of stereoscopic analysis greatly aids in lithologic and structural studies. It is recommended that users of ERTS-1 images for geologic studies be encouraged to apply the limited stereoscopic capability of ERTS-1 imagery to their investigations.

It has also been found that ERTS-1 imagery commonly contains more geologic information than can be adequately annotated on the 1:1,000,000 positive transparencies. It is recommended that future geologic interpretations utilize 2X (1:500,000) enlargements for annotation in conjunction with analysis of the higher quality 1:1,000,000 positive transparencies.

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